Some Alignment Instruments for SPring-8 Storage Ring Magnets

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1. Introduction

Alignment instruments were used to install magnets and girders efficiently and precisely. Before installation of magnets, fiducial points were marked along the beam lines.[1] We manufactured instruments for marking on the floor. When magnets and girders were installed, positioning instruments, such as a template, were used. It enables the alignment to perform efficiently, because arrays of magnets are repeated in the 48 cells. In addition, some instruments were used for checking of the alignment precision, and settlement surveys of the floor. These instruments are described in this paper.

2. Instruments

2-1 Puncher

Figure. 1 shows the cross section of the puncher. When magnets and girders are aligned, fiducial points on the floor are required. The puncher was used when the 88 fiducial points were made along the whole ring. It consists of a X-Y stage equipped with a micrometer, a scope, and a drill shaft. This is the instrument that has the capacity to mark points on the floor moved by the needed length from the center. The drill is inserted in the drill shaft. Therefore, it is possible to make a conical crater on the floor that is 0.5~0.6mm in diameter by turning the drill shaft clockwise a couple of times by hand.

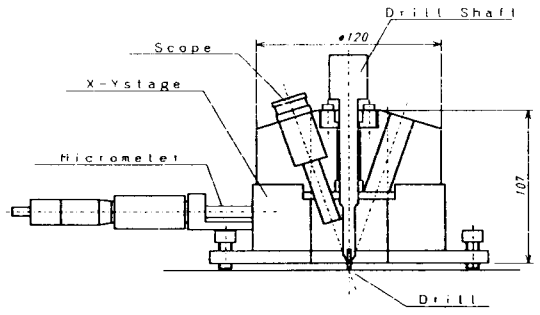

Fig. 1. Cross section of the puncher

In addition, when we mark on the floor using the laser tracker SMART 310, the puncher is used with a 3.5"-diameter retroreflector called Cat's Eye for the laser tracker SMART 310. The view of the puncher with the retroreflector is shown in Fig. 2. This is used in 66 beam lines in the tunnel, the injection line, and the area where cavities are installed. The shaft with the cup on which the retroreflector rests is used instead of the drill shaft. The position of the retroreflector is measured by the laser tracker SMART 310. Then the shaft is replaced to the drill shaft, and marked on the floor. It is possible to mark precisely by using the puncher and the laser tracker SMART 310.

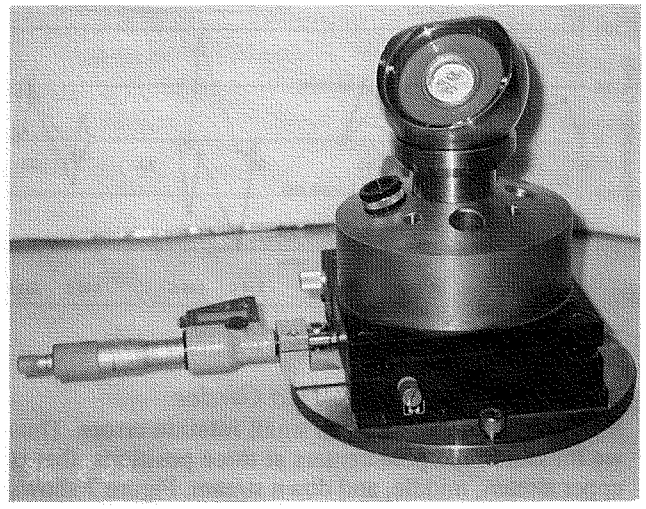

Fig. 2. View of the puncher with a retroreflector

2-2 Seal Sticker

WILD target seals, on which a fiducial circle and a cross hair are printed, were stuck on the floor to make fiducial points. The seal sticker was used to stick seals on the floor precisely. The structure of the seal sticker is similar to the puncher. The 3.5"-diameter retroreflector for the laser tracker SMART 310 rests on the shaft. The seal can be stuck at the spot which coincides with the center of the retroreflector. The positional accuracy to stick seals is 50 μ m. In addition, it is possible to measure the position of the seal by the laser tracker SMART 310.

2-3 Compass and Template

Girders and two magnets placed at both ends of the

girder were aligned according to two fiducial points on the floor

The compass in Fig. 3, which is the aluminum rectangular pipe to determine the length between the fiducial point and the girder, was used when girders are aligned in the beam direction. Girders were positioned so that the center of the needle at left end of the rectangular pipe coincides with the center of the fiducial point on the floor. It was possible to place girders in a short time precisely with this instrument.

The template in Fig 3 was used for positioning between two adjacent magnets. The template and its pedestals were placed on magnets. The template has holes at the spot that coincides with the center of socket holes of magnets. Magnets can be positioned by inserting the pin into holes. The holes of the template were machined in the air-conditioned room, and lengths between holes become designed lengths at 25℃ These instruments were inspected and calibrated by the laser tracker SMART 310.

Theodolites were used when magnets and girders were aligned in the X direction (perpendicular to the beam direction). The center of the theodolite was placed just over the fiducial point. The 3.5"-Taylor Hobson sphere with a cross hair was placed on the center of the magnet. Looking at the target by the theodolite, magnets were aligned. A tiltmeter (Nivel 20, Leica) and WILD N3 (or NA2) were used for a tilt measurement and an elevation measurement respectively.

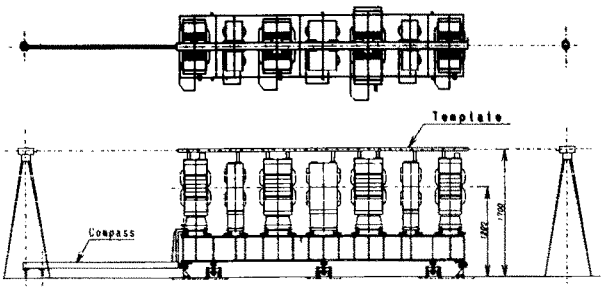

Fig. 3. Compass and Template

2-4 Instrument for the elevation measurement

The instrument, which measure the elevation difference between two magnets, was developed. It consists of an aluminum pipe with spheres positioned at both ends of the pipe, and a tiltmeter (Taylor Hobson Talyvel 4) positioned at the center of the pipe. This is shown in Fig. 4. The instrument was used for settlement surveys of the elevation.

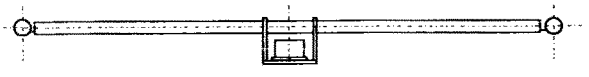

Fig. 4. Instrument for elevation measurement

2-5 Scale and Socket

A scale and a socket have been designed to measure the floor elevation. The temperature in the tunnel was not constant all the time during the construction period. The length of the scale should not depend on the room temperature. Therefore the structure in Fig. 5 is adopted. The material of the column is aluminum and iron with the different coefficient of heat expansion. Two columns are connected by the horizontal lever on top of columns. When the room temperature changes, the length of aluminum and iron changes by d, and 1.96d, respectively. However, the elevation of the lever at right end does not change. The 3.5"-diameter sphere target with PSD (Position Sensitive Device) rests at right end of the lever. The elevation is measured by a laser. Sockets are buried, and molded by epoxy resin.

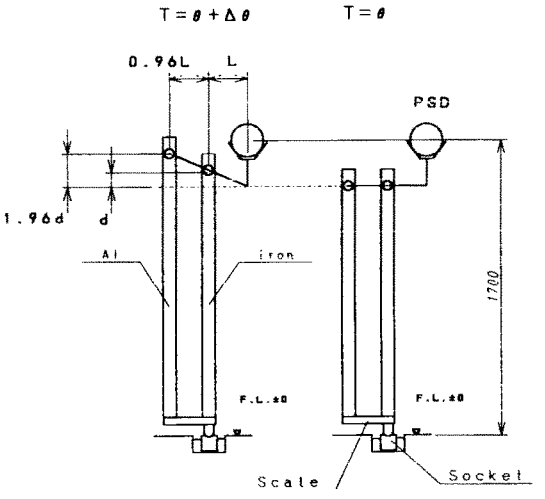

Fig. 5. Scale and Socket

References

[1] S. Matsui et al., Proc. 4th Int. Workshop on Accelerator Alignment (1995)